PIMA COUNTY
FLOOD CONTROL

MEMORANDUM

DATE: April 18, 2017

TO: Attendees Rosemont Hydrology/Water Quality 18 April, 2017 – USACE Phoenix

FROM: Evan Canfield, P.E
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HEC

SUBJECT: **Evaluating Effects of Rosemont Mine on Downstream Flows at Davidson Canyon**

BACKGROUND

As stated in the Rosemont Mine 401 Certification, the purpose of the Surface Water Mitigation Plan is *"to maintain aquatic and riparian resources at pre-project levels in the OAW portions of Davidson Canyon Wash and Lower Cienega Creek. The purpose of the plan is to detail the measures that will be taken to offset predicted reductions in surface water flows and sediment, resulting from the construction and operation of the Rosemont Copper Project, and a schedule for implementation of such measures."* [Specific Condition #1, CWA 401 Water Quality Certification, page 6]

Pima County has specific concerns about the methodology and data, which we believe is important to evaluate these effects including:

1. The Outstanding Arizona Water in Davidson Canyon has been perennial in the past and has always met the criteria for intermittent flow using USGS criteria:
    - *An intermittent stream flows only at certain times in the year, when it receives both ground-water discharge and storm runoff.. (Langbein and Iseri, 1960).*
2. Use of precipitation depths that are higher at higher elevations and lower at lower elevations in accordance with the orographic effects shown in NOAA and PRISM precipitation datasets.
3. Inadequate Model framework to estimate intermittent flow volumes from the mine site to Davidson Canyon.
4. Recent isotopic data suggesting a higher elevation source for the water in Davidson Creek and Cienega Creek.

This Memo Summarizes Those Concerns.

SUMMARY

1.) **The Estimate of Mine Area Impact On Downstream Annual Flow Volumes is Underestimated, Because Mean Annual Precipitation is Underestimated:**

a. Consultant's Estimate Does Not Take Into Account Spatial Rainfall Differences

SWCA has quantified the impact of the Barrel alternative as reducing downstream flows by 4.3 percent cited as SWCA 2012 come from a numerical calculation () that in turn cited Zeller 2011, which uses the calculation:

$$Q_{AAr} = \left(\frac{A_r}{A_n}\right)^{0.6636} Q_{AAn}$$ Eq 1

Where:

Q_{AAr} is the reduced average annual runoff (acre-ft)
Q_{AAn} is the average annual runoff under natural conditions (acre-ft)
A_r is the reduced watershed area assuming some diversion to mine (square miles)
A_n is the natural watershed area (square miles)

Since precipitation is not referenced in this equation, the equation clearly does not account for differences in annual rainfall at higher elevations in the watershed. In fact, Zeller 2011a uses a value of 18 inches:

$$QAAn \quad _{AAn} = A \quad ^{0.6636} p \quad ^{2.1086}$$ Eq 2

b. PRISM Comparison With Orographic Effects Show About 6" Deeper Rainfall Depth (Table 1)

Lat	Long	Elevation (ft)	Annual Precipitation (inch)*	Mean Annual Temp (F)*	
31.833	110.764	5793	23.9	61.0	Upper Watershed Rosemont Parcel
31.862	110.691	4361	18.0	62.2	Barrel at Hwy 83
31.984	110.646	3548	15.5	65.5	Top of Outstanding Waters
32.019	110.644	3332	15.0	66.0	Davidson Canyon At Confluence with Cienega
31.350	110.917	3802	17.9	62.2	Nogales

* 30-yr Normal Precipitation and Temperature Estimates from PRISM
http://prism.oregonstate.edu/normals/

Elevation of Rosemont Mine (inside Perimeter Fence from 2008 Lidar Data)

Minimum Elevation 4,561 ft

Maximum Elevation 6,107 ft

Mean Elevation 5,165 ft

2.) <u>The Simplified Regression Equation Does Not Adequately Account for Spatial and Temporal Difference Which Can Impact the Outstanding Waters</u>

The evaluation of downstream impacts used by Rosement includes only two inputs, Area (Eq 1), and Average Annual Precipitation (Eq 2), and is inadequate for evaluating effects at an intermittent stream like the Outstanding Arizona Waters in Davidson Canyon, which changes temporally.

a. A Conceptually More Complex Model Already Exists on a Monthly Timestep

Simplified Available Groundwater Recharge and Runoff Estimate (e.g. Flint and Flint, 2007 – Graphic Attachment A), and has been done for the larger Rillito Watershed on a 270m grid.

$$AW = P + Sm - PET - Sa + Ss$$

Where

AW - Water Available for Runoff and In Place Recharge (monthly)
P - Monthly Precipitation
Sm – Snow Melt
PET - Potential Evapotranspiration
Sa – Snow Accumulation
Ss – Soil Storage

Factors Affecting Available Water (Table 2)

Monthly Precipitation ↑	Potential Evapotranspiration ↓	Soil Storage ↓
Greater Rainfall on Mine Site Resulting in Greater Runoff from Mine Site and Other Mountainous Parts of the Watershed	Lower at Mine Site than Low Desert	Lower at Mine Site, which has little soil

On Mine Site

$$\Large AW = P \normalsize + Sm - {\scriptsize PET} - Sa + {\scriptsize Ss}$$

b. A Conceptually More Complex Model Calibrated to the Cienega Gauge Already Exists on a Daily Timestep

The Soil Water Assessment Tool (SWAT), a continuous simulation operating on a daily time step, which is suitable for evaluating Land Use Change. SWAT is used in the EPA BASINS (Better Assessment Science Integrating Point and Nonpoint Sources) modeling used to assist in watershed management and TMDL development.

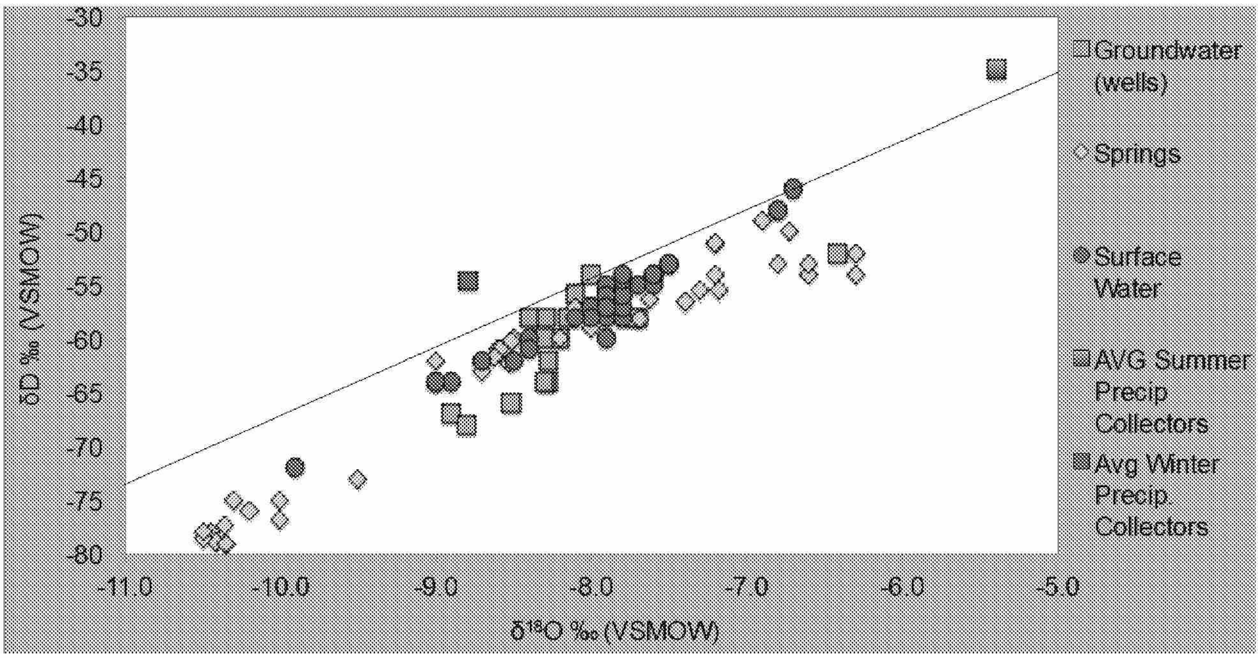
Because SWAT has been calibrated for the Santa Cruz River Basin using 14 gaging stations including Cienega Creek and Pantano Dam data (Niraula et al. 2015), and is used by the EPA to evaluate watershed management, I believe that it is an appropriate tool for evaluating the effects of the Rosemont Mine on flows and sediment within Davidson Canyon as required by the 401 certification.

Factors That Impact Daily Surface Runoff Volumes (Table 3)

Daily Precipitation	Infiltration	Steepness
Greater Rainfall on Mine Site Resulting in Greater Runoff from Mine Site and Other Mountainous Parts of the Watershed	More Rocky on Mine Site Resulting in Greater Runoff from Mine Site and Other Mountainous Parts of the Watershed	Steeper on Mine Site Resulting in Greater Runoff from Mine Site and Other Mountainous Parts of the Watershed

3.) <u>The Isotopic Data indicates That Flows in Davidson Canyon and Ciengega Creek Suggest Derivation from Winter Storms</u>

Recently collected isotopic data (McIntosh and Tucci, Unpublished data) indicate surface waters in Davidson and Cienega Creek more closely resemble winter precipitation, which disproportionately occurs at higher elevation (such as the mine site) suggesting a higher elevation source for the water in the Outstanding Waters.



CONCLUSIONS

1.) **The assessment conducted for Rosemont underestimated downstream flows by using underestimated annual rainfall.**

2.) **The modeling method used is inadequate to evaluate intermittent flows:** Since output from equation 1 is annual runoff volume, and flow in the Outstanding Arizona Waters is intermittent, it has no capacity to evaluate temporal change such as intermittent flow.

3.) **A model capable of evaluating temporal change is necessary for evaluations, such as the watershed diversions that occur in first 10 years of mine operations:** The riparian stand in Davidson Canyon depends on upstream contributions from infiltrated water and surface flow. In order to evaluate these during changing mine configurations.

4.) **Models capable of evaluating temporal change on daily and monthly timesteps have already been applied to this watershed:** <u>All conceptual considerations in the monthly and daily timestep models suggest higher runoff volumes from the mine site than the model currently being used.</u>

5.) **<u>Recently collected isotopic data indicate dominance of winter precipitation in Davidson and Cienega Creek – suggesting a higher elevation source.</u>**

REFERENCES

Flint L.E and Flint A.L. 2007. *Regional Analysis of Ground-Water Recharge*. USGS Professional Paper 1703—Ground-Water Recharge in the Arid and Semiarid Southwestern United States—Chapter B

Langbein, W.B., and Iseri, K.T., 1960, General introduction and hydrologic definitions, Manual of Hydrology: Part 1. General Surface-water Techniques: U.S. Geological Survey Water-Supply Paper 1541-A, p. 18. Legal Information Institute,

Niraula, R., Meixner, T., and Norman, L.M. 2015. *Determining the importance of model calibration for forcasting absolute/relative changes in streamflow from LULC and climate changes*. Journal of Hydrology Vol. 522 p. 439-451

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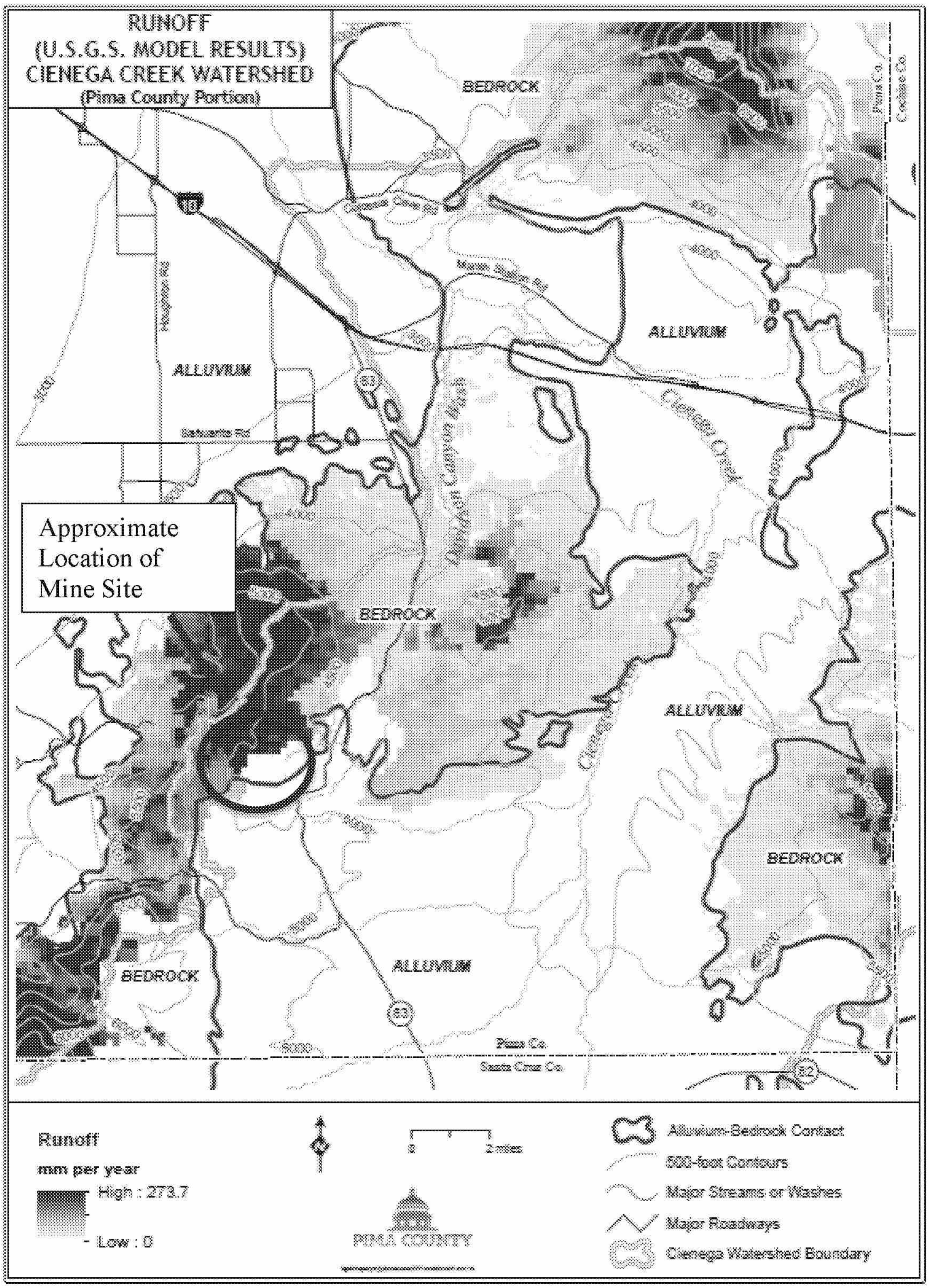
RUNOFF
(U.S.G.S. MODEL RESULTS)
CIENEGA CREEK WATERSHED
(Pima County Portion)
Approximate
Location of
Mine Site
BEDROCK
ALLUVIUM
Cienega Creek
Davidson Canyon Wash
Sahuarita Rd
Houghton Rd
Colossal Cave Rd
Marsh Station Rd
Pima Co.
Santa Cruz Co.
Cochise Co.
Runoff
mm per year
High : 273.7
Low : 0
0
2 miles
PIMA COUNTY
Alluvium-Bedrock Contact
500-foot Contours
Major Streams or Washes
Major Roadways
Cienega Watershed Boundary